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(54) Title: HER2 EXTRACELLULAR DOMAIN

(57) Abstract

An extracellular portion of the HER2 molecule, essentially free of transmembrane and cytoplasmic portions, which is antigenic in animals. Isolated DNA encoding the extracellular portion; an expression vector containing the isolated DNA; and a cell containing the expression vector. A process for producing the extracellular domain. A vaccine containing the extracellular domain.

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-1-

HER2 EXTRACELLULAR DOMAIN

BACKGROUND OF THE INVENTION

Field of the Invention

The present invention is generally directed to the
extracellular domain of p185^{HER2}, a receptor-like protein
which is encoded by the human homolog of the rat neu
oncogene.

More specifically, the present invention is directed
to a form of the extracellular domain which is essentially
free of transmembrane and cytoplasmic domains, to the DNA
encoding this form, and to a process for producing this
form of the extracellular domain in a host cell.

Description of Background and Relevant Materials

Human epidermal growth factor receptor 2 (HER2, also
known as NGL and human c-erbB-2, or ERBB2), is the human
homolog of the rat proto-oncogene neu. HER2 encodes a
1,255 amino acid tyrosine kinase receptor-like glycoprotein
with homology to the human epidermal growth factor
receptor. Although no ligand binding to this probable
growth factor receptor has yet been isolated, the HER2 gene
product, p185^{HER2}, has the structural and functional
properties of subclass I growth factor receptors (Yarden et
al., Ann. Rev. Biochem., 57:443-478 (1988); Yarden et al.,
Biochem., 27:3113-3119 (1988)).

The receptor tyrosine kinases all have the same
general structural m tif; an extracellular domain that
binds ligand, and an intracellular tyrosine kinase d main
that is necessary for signal transduction, or in ab rrant

-2-

cases, for transformation. These 2 domains are connected by a single stretch of approximately 20 mostly hydrophobic amino acids, called the transmembrane spanning sequence. This sequence is thought to play a role in transferring the

5   signal generated by ligand binding from the outside of the cell to the inside. It has also been suggested to play a role in the proper positioning of the receptor in the plasma membrane.

Consistent with this general structure, the p185^{HER2}

10   glycoprotein, which is located on the cell surface, may be divided into three principle portions: an extracellular domain, or ECD (also known as XCD); a transmembrane spanning sequence; and a cytoplasmic, intracellular tyrosine kinase domain. While it is presumed that the

15   extracellular domain is a ligand receptor, as stated above the corresponding ligand has not yet been identified.

The HER2 gene is of particular interest because its amplification has been correlated with certain types of cancer. Amplification of the HER2 gene has been found in

20   human salivary gland and gastric tumor-derived cell lines, gastric and colon adenocarcinomas, and mammary gland adenocarcinomas. Semba et al., Proc. Natl. Acad. Sci. USA, 82:6497-6501 (1985); Yokota et al., Oncogene, 2:283-287 (1988); Zhou et al., Cancer Res., 47:6123-6125 (1987); King

25   et al., Science, 229:974-976 (1985); Kraus et al., EMBO J., 6:605-610 (1987); van de Vijver et al., Mol. Cell. Biol., 7:2019-2023 (1987); Yamam to et al., Nature, 319:230-234 (1986). Gene transfer experiments have shown that

-3-

overexpression of HER2 will transform NIH 3T3 cells and
also cause an increase in resistance to the toxic
macrophage cytokine tumor necrosis factor. Hudziak et al.,
"Amplified Expression of the HER2/ERBB2 Oncogene Induces
5   Resistance to Tumor Necrosis Factor Alpha in NIH 3T3
Cells", Proc. Natl. Acad. Sci. USA 85, 5102-5106 (1988).

Because amplification of the HER2 gene results in
greatly increased numbers of the p185^{HER2} protein residing on
the surfaces of affected cells, there may be an
10   interrelationship between increased amounts of p185^{HER2}
extracellular domain on the surfaces of affected cells and
the resistance of these cells to treatment. It would
therefore be highly desirable to be able to manipulate the
p185^{HER2} extracellular domain in order to investigate several
15   possibilities for the treatment of conditions associated
with amplification of the HER2 gene. These therapeutic
modes relate not only to the extracellular domain, but also
to the putative ligand, which it should be possible to
isolate and characterize using the purified p185^{HER2}
20   extracellular domain.

SUMMARY OF THE INVENTION

The present invention is accordingly directed to an
extracellular portion of the HER2 molecule containing at
least 9 amino acids, and/or containing an immune epitope,
25   which is essentially free of transmembrane and
intracellular portions of the HER2 molecule. The
xtracellular portion may be substantially pure, or at
least about 99% pure, and may extend to the entire

-4-

extracellular portion of the HER2 molecule. M reover, the
extracellular portion may be antigenic in animals, and may
be conjugated with a peptide having immunogenic
properties; this peptide may contain an immune epitope.

5   In another embodiment, the present invention is
directed to isolated DNA encoding the extracellular portion
of the HER2 molecule. This isolated DNA terminates
upstream of the DNA portion encoding the transmembrane
domain of the HER2 molecule. The termination may occur at

10   least 1 base pair upstream of the portion encoding the
transmembrane domain of the HER2 molecule, and preferably
occurs about 24 base pairs upstream of this portion.

The isolated DNA of the present invention encodes a
sequence of at least 9 amino acids of the extracellular

15   portion, and none of the transmembrane or intracellular
portions of the HER2 molecule.

In a further embodiment, the present invention
contemplates an expression vector, such as a plasmid or
virus, containing the isolated DNA as described above, as

20   well as a cell containing the expression vector. This cell
may be eukaryotic or prokaryotic.

The present invention also extends to a process for
producing an extracellular portion of the HER2 molecule,
which includes the steps of ligating the isolated DNA as

25   described above into an expression vector capable of
expressing th isolated DNA in a suitable host;
transforming the host with the expression vect r;

-5-

culturing the host under conditions suitable for expressi n
of the isolated DNA and production of the extracellular
portion; and isolating the extracellular portion from the
host.   The host cell may be a prokaryote, such as a

5   bacterium, or a eukaryote.

       In a yet further embodiment, the present invention
extends to a vaccine comprising the extracellular portion
of the HER2 molecule, which may be combined with suitable
adjuvants.

10   BRIEF DESCRIPTION OF FIGURES

       Fig 1.   HER2 expression vector and full-length and
mutant HER2 proteins. The HER2 expression vector contained
eukaryotic transcriptional units for the mouse dihydro-
folate reductase (DHFR) cDNA and the bacterial neomycin

15   phosphotransferase (neo) gene, both under SV40 early
promoter control. Transcription of the full-length HER2
cDNA was also driven by the early SV40 promoter. The
full-length HER2 protein contains an extracellular domain
with two cysteine-rich clusters (hatched rectangle),

20   separated by the transmembrane-spanning region (filled
rectangle) from the intracellular tyrosine kinase domain
(open rectangle). The mutant protein $p185^{HER2\Delta TM}$ has a
deletion of 28 amino acids, including the
transmembrane-spanning region. The truncated $p185^{HER2XCD}$

25   protein contains all N-terminal sequences up to 8 amino
acids before the transmembrane-spanning region.

       Fig. 2.   Amplification of HER2 and HER2ΔTM g nes.
Cell lin s transfected with plasmids expressing wild type

-6-

or the ΔTM mutant HER2 cDNAs were amplified to resistance to 400 nM methotrexate. Cultures were metabolically labeled with [^{35}S]-methionine and proteins immuno-precipitated with the G-H2CT17 antibody. Lane 1:

5   CVN-transfected NIH 3T3 vector control line. Lanes 2 and 3: Parental and amplified HER2-3 line. Lanes 4, 5, and 6, 7: Parent and amplified lines derived from two independent clones, A1 and B2, of the ΔTM mutant. The arrows indicate the positions expected for proteins of apparent molecular

10   mass of 175 and 185 kDa.

Fig. 3. Autophosphorylation of p185^{HER2} and p185^{HER2ΔTM} proteins. Triton X-100 lysates of control, HER2-3$_{400}$, and ΔTM-expressing cell lines were prepared and immuno-precipitated with the G-H2CT17 antibody. The immune

15   complexes were incubated in 50 ul of HNTG, 5 mM MnCl2 with 3 uCi [γ-^{32}P] for 20 min, electrophoresed on a 7.5% polyacrylamide gel, and labeled bands visualized by autoradiography. Lane 1: CVN vector control. Lane 2: HER2-3$_{400}$ cells expressing full-length HER2. Lanes 3 and 4:

20   Two independent lines expressing p185^{HER2ΔTM}. The arrows indicate the positions expected for proteins of apparent molecular mass of 66.2, 97, 175, and 185 KDa.

Fig 4. Secretion assay of ΔTM mutants. Cell lines CVN, HER2-3$_{400}$, ΔTM-A1$_{400}$, and ΔTM-B2$_{400}$ were labeled with [^{35}S]-

25   methionine overnight. Triton X-100 cell extracts were prepared and the labeling medium collected. Cells and cell-conditioned media were immunoprecipitated with G-H2CT17 antibody and analyzed on 7.5% SDS-PAGE gels.

-7-

Lanes 1-4 are immunoprecipitations of cell extracts from the various lines, and lanes 5-8 are immunoprecipitations from the corresponding cell-conditioned media. Lanes 1 and 5: CVN vector control. Lanes 2 and 6: HER2-3$_{400}$ cell lines expressing full-length p185^{HER2}. Lanes 3, 4 and 7, 8: ΔTM-A1$_{400}$ and ΔTM-B2$_{400}$ cell lines expressing mutant p185$^{HER2\Delta TM}$. The arrows indicate the positions expected for proteins of apparent molecular mass of 175 and 185 KDa.

Fig 5. Secretion of p185^{HER2XCD} from 3T3 and CHO cells. NIH 3T3 and CHO cell lines expressing full-length and truncated p185^{HER2} and vector controls were labeled with [^{35}S]-methionine overnight. Cell extracts and cell-conditioned media were immunoprecipitated with anti-HER2 monoclonal antibody 3E8 and analyzed on 7.5% SDS-PAGE gels. Lanes 1 and 2: NIH 3T3 control cell line, extract and conditioned medium. Lanes 3 and 4: NIH 3T3 line A1 expressing p185^{HER2XCD}, cells and medium. Lanes 5 and 6: NIH 3T3 line 3$_{400}$ expressing full-length p185^{HER2}, cells and conditioned medium. Lanes 7 and 8: CHO control line, cell extract and conditioned medium. Lanes 9 and 10: CHO line 2, expressing p185^{HER2XCD}, cells and conditioned medium. Lanes 11 and 12: CHO line HER2$_{500}$, expressing full-length p185^{HER2}, cells and conditioned medium. The arrows indicate the molecular mass of the indicated protein bands.

Fig 6. Increase in expression of p185^{HER2XCD} with amplification. The CHO-derived cell line HER2XCD-2 was selected for growth in 500 nM and then 3000 nM methotrexate. The parent line, the two amplified

-8-

derivatives, and control vector-transfected cells were
labeled with [^{35}S]-methionine.   Cell extracts and
cell-conditioned media were immunoprecipitated with the
anti-HER2 monoclonal antibody 3E8 and analyzed on a 7.5%

5   SDS-PAGE gel.   Lanes 1 and 2: CVN cell extract and
conditioned medium. Lanes 3 and 4: HER2XCD-2, unamplified
cells and conditioned medium.   Lanes 5 and 6: HER2XCD-2
amplified to resistance to 500 nM methotrexate, cells and
conditioned medium. Lanes 7 and 8: HER2XCD-2 amplified to

10   resistance to 3000 nM methotrexate, cells and conditioned
medium. For comparative purposes, one-fifth as much sample
of the 3000 nm line was loaded compared to the control, 0
nM, and 500 nM lines.   The band intensities were
quantitated with an LKB2202 laser densitometer. The arrows

15   show the positions of proteins of apparent molecular mass
of 88 and 103 KDa.

       Fig 7.   Biosynthesis of p185^{HER2XCD}.   The CHO line
HER2XCD2$_{3000}$ was labeled with [^{35}S]-methionine and cell
extracts, and cell-conditioned media prepared. Lanes 1 and

20   2: Cell extract and cell-conditioned medium.   Lanes 3 and
4: The same conditioned medium incubated or mock-incubated
with endo H.   Lanes 5 and 6: Cell extract and conditioned
medium from cells treated with tunicamycin.   The arrows
show the positions expected for proteins of apparent

25   molecular mass of 73, 88, and 103 KDa.

       Fig 8.   M rphology of NIH 3T3 cells transfected with
HER2 and HER2ΔTM expression constructs.   A and D: Parental
and amplified cells fr m NIH 3T3 cells transfected with

-9-

vect r alon . B and E: NIH 3T3 cells expressing p185$^{HER2\Delta TM}$

(line A1), parent and amplified derivative selected for

resistance to 400 nM methotrexate. C and F: NIH 3T3 cells

expressing wild type p185^{HER2} (line 3), parent and amplified

5   derivative selected for resistance to 400 nM methotrexate.

        Fig 9.   Cell surface and cytoplasmic immuno-

fluorescence staining of control, HER2, and HER2ΔTM lines.

The top photos are intact cells labeled with anti-HER2

monoclonal antibody. The bottom photos are the same cell

10   lines treated with 0.15% Triton X-100 detergent before

addition of antibody. A and D: Control NIH 3T3 cells

transfected with vector only. B and E: Cell line HER2

ΔTM-A1$_{400}$, expressing p185HER2ΔTM.   C and F: Cell line

HER2-3$_{400}$ expressing p185^{HER2}.

15   Fig 10. Fluorescence-activated cell sorter histograms

of control, HER2 and HER2ΔTM cells binding anti-p185^{HER2}

monoclonal antibody 4D5. Binding by the control antibody,

368, directed against human tissue plasminogen activator,

light, broken line. Binding by the anti-HER2 antibody 4D5,

20   dark unbroken line. Panel A: Control NIH 3T3 cells

transfected with vector only. Panel B: Cell line HER2-3$_{400}$,

expressing p185^{HER2}.   Panel C: Cell line HER2   ΔTMA1$_{400}$

expressing p185$^{\Delta TM}$.

        Fig 11. Biosynthesis of p185^{HER2} and p185$^{HER2\Delta TM}$ proteins.

25   Cell lines HER2-3$_{400}$ and HER2ΔTM-A1$_{400}$ were labeled with

[^{35}S]-methionine and p185^{HER2} and p185$^{HER2\Delta TM}$ proteins collected

by immunoprecipitation and analyzed on a 7.5% SDS-PAGE gel.

Lane 1: Vector control. Lane 2: Untreated p185$^{HER2\Delta TM}$. Lanes

-10-

3 and 4: Aliqu ts of the same cell extract treated r mock-treated with endo H. Lane 5: Nonglycosylated p185^{HER2} from cells treated with tunicamycin. Lane 6: Untreated p185^{HER2}. Lanes 7 and 8: Aliquots of the same cell extract
5   treated or mock-treated with endo H. Lane 9: Nonglycosylated p185$^{HER2\Delta TM}$ from cells treated with tunicamycin. The arrows show the positions of proteins of apparent molecular weight of 175 and 185 kDa.

Fig. 12. Purification of the HER2 extracellular
10 domain. Purified HER2 extracellular domain samples were analyzed using PhastSystem SDS-Gel electrophoresis and silver stained protocols as recommended by Pharmacia. SDS polyacrylamide gel (10-15% gradient) electrophoretic analysis was performed according to Pharmacia protocol File
15 No. 110. Silver staining was performed according to Pharmacia protocol File No. 210. Lane 1 contains molecular weight markers (BRL). Lane 2: Chinese Hamster Ovary Cell 15 X concentrate (1 microliter). Lanes 3 and 4: immunoaffinity purified HER2 extracellular domain (1.6
20 micrograms and 0.16 microgram, respectively). Lanes 5 and 6: immunoaffinity purified HER2 extracellular domain after DEAE chromatography (0.25 micrograms and 0.083 micrograms, respectively). Lanes 7 and 8: HER2 extracellular domain after formulation in PBS (0.32 micrograms and 0.082
25 micrograms, respectively).

Fig. 13. The predicted amino acid sequence of the HER2 extracellular d main, with the corresponding nucleic acid sequence. The boxed sequences sh w potential T-cell

-11-

pitopes, using the algorithm developed by Margolit <u>et al.</u>,
J. Immunol. 138:2213-2229(4) (1987).

<u>DETAILED DESCRIPTION</u>

It was initially hypothesized that removal of the
5   transmembrane spanning sequence would yield a protein which
would be secreted from the cell. As previously indicated,
the transmembrane spanning sequence is principally composed
of hydrophobic amino acids, which effectively anchor the
protein in the cell membrane. Removal of this sequence
10 would therefore be expected to permit passage of the
protein through the membrane.

A first construct was accordingly prepared which
deleted exactly in-frame the 22 amino acid transmembrane
spanning sequence of HER2, and 3 amino acids on either side
15 (Figure 1). The construct was prepared as follows:

The central EcoR1 fragment containing the trans-
membrane spanning segment was cloned into the EcoR1 site of
the bacteriophage vector M13 mp18 (Yanisch-Perron <u>et al.</u>,
<u>Gene</u>, 33:103-119 (1985). The noncoding strand was used as
20 template for oligonucleotide-directed mutagenesis. The
construct deleted the transmembrane spanning sequence, and
an additional 3 amino acids before and after.

Residues 651-678 were deleted by priming double
stranded DNA synthesis with a 30 base pair oligonucleotide
25 of sequence 5' CAG AGA GCC AGC CCT CAG CAG AAG ATC CGG 3'.
The double stranded DNA was transf rmed into SR101 cells
and mutants identified by hybridization to the same
oligonucleotide 5' end labeled by polynucleotide kinase and

-12-

[γ-^{32}P] ATP (Amersham, 5000 Ci/mm 1). An Ec R1 fragment containing the deletion was recombined into a plasmid expressing the HER2 cDNA, replacing the wild type sequence.

When expressed in NIH 3T3 cells, this mutant, designated HER2$^{\Delta TM}$, produced a polypeptide, designated p185$^{HER2\Delta TM}$, of apparent molecular weight 175 kD (Figure 2, lanes 5 and 7). Production took place at levels comparable to wild type p185^{HER2} amplified to the same level of resistance to methotrexate (Figure 2, lane 3). The mutant proteins also retained an active tyrosine kinase activity.

In the presence of [γ-^{32}P]-ATP, the mutant proteins (Figure 3, lanes 3 and 4) were autophosphorylated to the same extent as unaltered p185^{HER} (Figure 3, lane 2). Figure 3 also shows autophosphorylated p185$^{HER2\Delta TM}$-related proteins of lower molecular weight than the complete protein. These smaller proteins may represent degradation products and, since they are not observed with p185^{HER2}, could imply a difference in intracellular processing of the mutant form.

To determine whether the form lacking the transmembrane sequence was secreted, cells were metabolically labeled with ^{35}S-methionine. The culture conditions used herein were as follows: cells were cultured in a 1:1 mixture of Dulbecco's modified Eagle's medium and Ham's nutrient mixture F-12 supplemented with glutamine (2 mM), penicillin (100 units/ml), streptomycin (100 ug/ml), and 10% serum. NIH 3T3-derived cell lines were cultured with calf serum (Hyclone). Chinese Hamster Ovary cells deficient in dihydrofolate reductase (CHO-DHFR) were

-13-

cultured in fetal bovine serum (Gibco) supplement d with glycine (0.13 mM), hypoxanthine (0.11 mM), and thymidine (0.02 mM). (For selection of the transfected plasmid DHFR gene or to amplify introduced plasmids by methotrexate

5   selection, the glycine, hypoxanthine, and thymidine were omitted and extensively dialyzed serum substituted for fetal bovine serum.)

Both cells and cell-conditioned medium were assayed for p185^{HER2}. Figure 4 demonstrates that all p185^{HER2} remained

10   cell associated (lanes 2, 3, 4), and neither the wild type protein nor the mutant form was secreted (lanes 6, 7, 8).

Thus, contrary to expectations, deletion of the transmembrane spanning sequence was not sufficient to yield a secreted form of p185^{HER2}.

15   The discovery that p185HER$^{2\Delta TM}$ is not secreted suggested that perhaps there are sequences distal to the transmembrane spanning region that prevent passage of p185^{HER2} through the plasma membrane. A second mutant was accordingly made that contained a UAA stop codon 8 amino

20   acids before the beginning of the proposed transmembrane spanning sequence (Figure 1).

The second construct truncated p185^{HER2} 8 amino acids before the start of the transmembrane spanning region at residue 645 by addition of a polypeptide chain-terminating

25   TAA codon. The oligonucleotide 5' AAG GGC TGC CCC GCC GAG TAA TGA TCA CAG AGA GCC AGC CCT 3' was used to prime synthesis of double-stranded DNA from the same template used to construct the ΔTM mutant. Mutant plaques were

-14-

identified by hybridization to the 5' end-labeled oligonucleotide, and confirmed by checking for the presence of a Bcl 1 site also introduced directly after the ochre codon. The chain-terminated mutant, designated HER2^{XCO}, was

5 then recombined into the HER2 cDNA expression plasmid. The structure of the plasmid and the 2 mutant HER2 derivatives is shown in Figure 1.

Secretion of the resulting form of p185^{HER2}, designated p185^{HER2XCO}, was assayed by first metabolically labeling the

10 cells with ^{35}S-methionine, followed by immunoprecipitation of p185^{HER2}-related proteins from both the cells and cell-conditioned media. In the immunoprecipitation procedure (Hudziak et al., Proc. Natl. Acad. Sci. USA, 84:7159-7163 (1987)), cells were harvested by

15 trypsinization, counted electronically with a Coulter counter, and plated at least 6 hrs. before labeling. The plating medium was removed, cells washed with PBS, and the cells re-fed with methionine-free Dulbecco's modified minimal medium. [^{35}S]-methionine (Amersham, 800 Ci/mmol,

20 29.6 TBq/mmol) was added at 100 uCi/6 cm plate in a volume of 3 ml. Cells were lysed at 4°C with 0.4 ml of HNEG lysis buffer per 6 cm plate. After 10 min, 0.8 ml of lysis dilution buffer (HNEG buffer with 1% bovine serum albumin, 0.1% Triton X-100 detergent) was added to each plate and

25 the extracts were clarified by microcentrifugation for 5 min. Medium to be assayed for secretion of p185^{HER2} related proteins was collected and clarified by micro-centrifugation.

-15-

Antib dies were added to cell extracts or c nditioned
medium and allowed to bind at 4°C for 2-4 h. The polyclonal
antibody, G-H2CT17(0), recognizing the carboxy-terminal 17
amino acids of p185^{HER2}, was used for characterization of
5   cell lines expressing the transmembrane-deleted form of
p185^{HER2}.   The monoclonal antibody 3E8, recognizing an
epitope on the extracellular domain (Hudziak _et al._, _Mol._
Cell. Bio., 9:1165-1172 (1989)), was used at 8 ug/reaction
to immunoprecipitate the truncated form.   Seven ug of
10   rabbit anti-mouse IgG was added to immunoprecipitations
using this monoclonal to improve its binding to protein
A-sepharose. Immune complexes were collected by absorption
to protein A-sepharose beads and washed (Hudziak _et al._,
Proc. Natl. Acad. Sci. USA, 85:5102-5106 (1988); Hudziak _et_
15   _al._, _Proc. Natl. Acad. Sci. USA_, 84:7159-7163 (1987)).
Proteins   were   separated   on   7.5%   sodium   dodecyl
sulphate-polyacrylamide gels (SDS-PAGE) and analyzed by
autoradiography.

This revealed a form of p185^{HER2XCD} of M_r 88,000 kD that
20   is associated with the cells (Figure 5, lanes 3 and 9);
however, the cell-conditioned media from both the NIH 3T3
cells and Chinese hamster ovary-derived lines also contains
larger amounts of a protein of M_r 103,000, which is
immunoprecipitated by anti-HER2 monoclonal antibody (Figure
25   5, lanes 4 and 10). Full length p185^{HER2} was also expressed
in both NIH 3T3 and CHO cells (Figure 5), lanes 5 and 11.
There is no secretion of native p185^{HER2} fr m either of these
cell types (Figure 5, lanes 6 and 12).

-16-

The larger size f the observed proteins in the cells and cell-conditioned medium (88,000 and 103,000, respectively) compared to the size predicted by the amino acid sequence (71,644) suggested that the truncated form

5   was being glycosylated.

This was confirmed by treating the cells with the antibiotic tunicamycin, which prevents N-linked glycosylation. Treatment with tunicamycin resulted in the appearance of a cell-associated protein of M_r 73,000, which

10 is close to that predicted by the amino acid sequence (Figure 7, lane 5). It also almost completely inhibited secretion of p185^{HER2XCD} into the medium (Figure 7, lane 6). Cell-conditioned medium from tunicamycin treated cells contains only small amounts of the mature 103,000 form, and

15 none of the smaller forms (lane 6). This further suggests that secretion of p185^{HER2XCD} is coupled to glycosylation.

The extent of glycosylation of the secreted form was investigated with the enzyme endoglycanase H (endo H, Boehringer Manheim). This enzyme will hydrolyze

20 asparagine-linked oligosaccharides of the high mannose type. High mannose oligosaccharides are biosynthetic intermediates in the glycosylation process. Final maturation of the carbohydrate side chains involves trimming off some mannose and addition of other sugars such

25 as fucose. Such mature oligosaccharide side chains are resistant to endo H.

To determine if secreted p185^{HER2XCD} is resistant to this enzyme, cell conditioned medium labeled with ^{35}S-m thionine

-17-

was immunoprecipitated. Th immuno-precipitates were collected onto protein A sepharose beads and incubated with endo H. Neither mock incubated (lane 3) nor endo H-treated p185^{HER2XCD} (lane 4) showed any decrease in mobility associated with hydrolysis of the glycosyl side chains, demonstrating that the glycosylation is complete.

Without being bound by any particular theory, these results taken together suggest that the cell-associated form of p185^{HER2XCD} is an intermediate, and that fully mature glycosylated p185^{HER2} extracellular domain is being synthesized and secreted. The lack of secretion of the p185$^{HER2\Delta TM}$ protein could be hypothesized to result from the presence of processing information in the transmembrane spanning sequence which is necessary for Golgi transport and targeting of the plasma membrane; however, from these studies it appears instead that transport of tyrosine kinase receptor (or receptor-like) extracellular domain to the cell surface is coupled to proper glycosylation.

Therefore, insertion of the UAA stop codon 8 amino acids before the beginning of the proposed transmembrane spanning sequence yields a fully mature glycosylated p185^{HER2} extracellular domain which is freely secreted by the cell.

Having succeeded in producing a secreted form of p185^{HER2}, the next stage involved investigating whether the amount of secreted protein could be increased by gene amplification. Using the CHO-d rived cell line, it was found that the amount of extracellular domain could be incr ased by methotrexate selection. The amount of

-18-

s creted product increased 29-fold in cells selected for resistance to 500 nm methotrexate, and a further 4.4-fold by selection for resistance to 3000 nm methotrexate (Fig. 6).

5   Thus, a total increase of 128-fold in secreted p185[HER2XCD] was obtained when this cell line was amplified to resistance to 3000 nm methotrexate, making the production of relatively large quantities of p185[HER2XCD] possible.

       To determine whether overexpression of p185[HER2ΔTM]
10   results in cell transformation, DNA was introduced in mammalian cells by the CaHPO$_4$ coprecipitation method (Graham et al., Virology, 52:456-467 (1973)). Five ug of plasmid DNA was added to half-confluent plates of cells (6.0 cm) in 1 ml for 4-6 h. The DNA was removed and the cells shocked
15   with 20% (vol/vol) glycerol. After 2 days for phenotypic expression the selective agent geneticin was added at 400 ug/ml. Clones were picked using glass cloning cylinders with petroleum jelly for the bottom seal. The introduced plasmids were amplified by the methotrexate selection
20   procedure (Kaufman et al., J. Mol. Biol., 159:601-621 (1982)).

       When the ΔTM mutant was expressed in NIH 3T3 cells, primary unamplified colonies after selection had the normal flat nontransformed phenotype (Figure 8, compare photo B
25   with vector control alone, photo A). After the expression level was increased by m thotrexate selection, the cells t ok on the refractile, spindle-shaped appearance of transformed cells and also grew piled up in irr gular

-19-

clumps (photo E).   This observation is similar to our
earlier findings with the unaltered HER2 cDNA (photos C and
F, parent and amplified derivatives respectively), and
suggests that high levels of expression of the mutant ΔTM
5   protein were also transforming.

The morphological changes seen at equivalent levels of
amplification (400 nm methotrexate) are not as marked for
the mutant, implying that the transforming potential of
this form of p185^{HER2} may be less.   At higher levels of
10   resistance to methotrexate, the ΔTM cells become even more
transformed in appearance.

The plasmid was also negative in a focus-forming assay
whereas the wild type HER2 plasmid was positive, further
indicating that the transforming potential of p185^{HER2ΔTM}
15   protein is lower.   Cells expressing high levels also
displayed another property of the transformed phenotype,
growth in soft agar.   Colony formation in soft agar was
determined by harvesting each line to be assayed with
trypsin, counting the cells (Coulter counter), and plating
20   80,000 cells per 6-cm dish.   The top layer consisted of 4
ml of 0.25% agar (Difco, "purified") over a bottom layer of
5 ml of 0.5% agar.   Colonies were counted after 3-4 weeks.
Cells from 2 independent clones plated in soft agar gave
rise to soft agar colonies with an efficiency comparable to
25   cells expressing the wild type HER2 gene:

-20-

Table I
Soft Agar Colony Formation

Cell Line	# of Soft Agar Colonies
CVN	0
CVN$_{400}$	0
HER2-3$_0$	5 +/- 1
HER2-3$_{400}$	208 +/- 27
ΔTM-A1$_0$	0
ΔTM-A1$_{400}$	205 +/- 62
ΔTM-B2$_0$	0
ΔTM-B2$_{400}$	205 +/- 13

Two control lines were used; NIH 3T3 cells transfected with a plasmid expressing only the neo and DHFR genes, and the same line amplified to resistance to 400 nM methotrexate. The number of soft agar colonies arising was determined for both parental and amplified lines of clones expressing either p185^{HER2} or p185^{HER2ΔTM} proteins. Each cell line was plated in triplicate and the value averaged.

Therefore, according to the present invention it has been determined that removal of only the transmembrane spanning sequence does not lead to secretion of p185^{HER2}, unless the entire tyrosine kinase domain is also deleted. Removal of this domain results in proper glycosylation and secretion of the extracellular domain.

In order to obtain purified HER2 extracellular domain working material, Chinese Hamster Ovary Cell Harvest Fluid (CFF) containing recombinant HER2 ECD may be first concentrated by ultrafiltration, and then purified by immunoaffinity chromatography using a HER2 specific MAb

-21-

coupled to CNBr activated Sepharose; other suitable immobilization supports may be used. Concentrated CCF is applied to the affinity column after filtration through a 0.2 micron Millipor filter. Purification cycles are

5   performed as necessary until the desired amount of CCF is processed.

During each cycle of purification, the concentrated CCF is applied and the affinity column is washed to baseline with 0.5 M Tris buffer containing 0.15 M NaCl at

10 a pH of approximately 7.5 (TB). HER2 extracellular domain is then eluted from the column with 0.1 M sodium citrate buffer containing 0.5 M NaCl at a pH of approximately 3.5. The affinity column eluant fractions containing HER2 ECD are pooled and neutralized. The immunoaffinity column is

15 reequilibrated between each purification cycle with TB.

In a second step, the affinity column eluant is buffer exchanged into 25 ml of Tris buffer, at a pH of approximately 7.0 (TB2). The HER2 extracellular domain is then applied to a DEAE Sepharose Fast Flow column, and

20 washed with TB2. The HER2 ECD is removed from the column by step or gradient salt elution in TB2 (containing up to 200 mM NaCl).

After DEAE chromatography, purified HER2 ECD fractions are pooled, exchanged into phosphate-buffered saline, and

25 stored at 2-8° C. The resulting material is substantially pure, i. ., about 99% pure (see Fig. 12).

By m ans of the pres nt invention it is accordingly possible to produc a secreted, glycosylated p185^{HER2}

-22-

extracellular d main. This opens several possibilities for further research, as well as a broad range of potential therapeutic applications.

As previously stated, the HER2 gene is of particular
5   interest because its amplification has been correlated with certain types of cancer. In a survey of 189 primary mammary gland adenocarcinomas, it was found that 30% contained amplifications of the HER2 gene. Slamon et al., "Human Breast Cancer: Correlation of Relapse and Survival
10   with Amplification of the HER-2/neu Oncogene," Science 235, 177-182 (1987). Amplification was correlated with a negative prognosis and high probability of relapse.

This suggests that of the 120,000 women diagnosed with breast cancer each year, 36,000 will have HER2
15   amplification. Approximately half of these women, or about 15,000, may be expected to exhibit greater than 5-fold amplification, corresponding to nearly half of the 40,000 breast cancer-related deaths each year.

It has been demonstrated that a monoclonal antibody
20   directed against the p185^{HER2} extracellular domain specifically inhibits growth of breast tumor-derived cell lines overexpressing the HER2 gene product; prevents HER2-transformed NIH 3T3 cells from forming colonies in soft agar; and reduces the resistance to the cytotoxic effect of
25   tumor necrosis factor alpha which accompanies HER2 overexpression. Hudziak et al., "p185^{HER2} Monoclonal Antibody has Antiproliferative Effects In Vitro and Sensitizes Human Breast Tumor Cells to Tumor Necrosis

-23-

Factor", _Mol. Cell. Biol._ 9:1165-1172 (1989). _See also_,

Drebin _et al_., "Inhibition of Tumor Growth by a Monoclonal

Antibody Reactive with an Oncogene-Encoded Tumor Antigen",

Proc. Natl. Acad. Sci. USA 83, 9129-9133 (1986) (_in vivo_

5   treatment with anti-p185 monoclonal antibody asserted to

inhibit tumorigenic growth of neu-transformed NIH 3T3 cells

implanted in mice).

This effect presents the possibility that conditions

characterized by amplification of the HER2 gene may be

10   subject to treatment via Active Specific Immunotherapy.

This therapeutic modality contemplates provoking an immune

response in a patient by vaccination with an immunogenic

form of the extracellular domain. The extracellular domain

(or a derivative thereof, as discussed below) may be

15   combined with a local adjuvant which is safe and effective

in humans, such as alum, Bacillus calmette-Guerin (BCG),

adjuvants derived from BCG cell walls, Detox (Ribi-

immunochem), Syntex-1, or Corynebacterium parvum.

Alternatively, systemic adjuvants, such as Interferon

20   gamma, Interleukin 1, Interleukin 2, or Interleukin 6 may

be suitable. An appropriate dose and schedule would be

selected to maximize humoral and cell-mediated response.

It may also be possible to enhance an immune response

by targeting the immunogen to the immune system, which

25   could lead to more efficient capture of the antigen by

antigen presenting cells, or by directing the immunogen so

that it is presented by MHC Class 1 mol cules, since th se

usually induce a T-cell response.

-24-

In addition to Active Sp cific Immunotherapy, it should be possible to use the purified extracellular domain to isolate and characterize the putative ligand. The HER2 ligand may be used in turn to deliver toxin to tumor cells

5   which are overexpressing HER2, such as by molecular fusion of the ligand with toxin, or by chemical cross-linking. Alternatively, patients overexpressing HER2 may be vaccinated with HER2 ligand conjugated to, or in combination with, a suitable adjuvant.

10   A patient overexpressing HER2 will also presumably be overexpressing the HER2 ligand. The ligand-HER2 binding interaction, which is likely to contribute to tumor growth, may be inhibited by blocking free ligand in the patient's serum. This blocking can be accomplished by treating the

15   patient with the HER2 extracellular domain, which will proceed to bind free HER2 ligand, thereby preventing the ligand from binding to the HER2 receptor site.

Rather than using the HER2 extracellular domain per se, it may be more desirable to use a derivative which has

20   an increased affinity for the ligand, and/or which has an increased half-life in vivo. Cross-linking on cells is known to improve binding affinity, suggesting that artificial cross-linking can be used to improve the binding ability of the HER2 extracellular domain. The half-life of

25   the extracellular domain in serum can be improved by, for example, fusing the extracellular domain with other molecules present in the serum which are known to have a

-25-

long half-life, such as the Fc-p rtion of an immun gl bin molecule.

The present invention has of necessity been discussed herein by reference to certain specific methods and
5 materials. It is to be understood that the discussion of these specific methods and materials in no way constitutes any limitation on the scope of the present invention, which extends to any and all alternative materials and methods suitable for accomplishing the ends of the present
10 invention.

-26-

WHAT WE CLAIM IS:

1. An extracellular portion of the HER2 molecule comprising at least 9 amino acids, essentially free of transmembrane and intracellular portions of said HER2
5   molecule.

2. An extracellular portion of the HER2 molecule comprising an immune epitope, essentially free of transmembrane and intracellular portions of said HER2 molecule.

10   3. The extracellular portion as defined by claim 1, in substantially pure form.

4. The extracellular portion as defined by claim 1, having a purity of at least about 99%.

5. The extracellular portion as defined by claim 1,
15   wherein said extracellular portion is antigenic in animals.

6. The extracellular portion as defined by claim 1, further comprising the entire extracellular portion of said HER2 molecule.

7. The extracellular portion as defined by claim 1,
20   conjugated with a peptide having immunogenic properties.

8. The extracellular portion as defined by claim 7, wherein said peptide comprises an immune epitope.

9. Isolated DNA encoding the extracellular portion as defined by claim 1, terminating upstream of the portion
25   encoding the transmembrane domain of said HER2 molecule.

10. The isolated DNA as defined by claim 9, terminating at least 1 base pair upstream of the portion encoding the transmembrane domain of said HER2 m lecule.

-27-

11. The isolated DNA as defined by claim 10, terminating about 24 base pairs upstream of the portion encoding the transmembrane domain of said HER2 molecule.

12. The isolated DNA as defined by claim 9, wherein
5 said DNA encodes a sequence of at least 9 amino acids of said extracellular portion, and none of the transmembrane or intracellular portions of said HER2 molecule.

13. An expression vector comprising the isolated DNA as defined by claim 9.

10 14. The expression vector as defined by claim 13, wherein said expression vector is a virus.

15. A cell into which the expression vector as defined by claim 13 has been introduced.

16. The cell as defined by claim 15, wherein said cell
15 is a prokaryote.

17. The cell as defined by claim 15, wherein said cell is a eukaryote.

18. A process for producing an extracellular portion of the HER2 molecule, comprising the steps of:
20 a) ligating the isolated DNA as defined by claim 9 into an expression vector capable of expressing said isolated DNA in a suitable host;

b) transforming said host with said expression vector;

c) culturing said host under conditions suitable for
25 expression of said isolated DNA and production of said extracellular portion; and

d) isolating said extracellular porti n fr m said host.

-28-

19. The process as defin d by claim 18, wherein said host cell is a prokaryote.

20. The process as defined by claim 19, wherein said prokaryote is a bacterium.

5   21. The process as defined by claim 18, wherein said host cell is a eukaryote.

22. A vaccine comprising the extracellular portion of the HER2 molecule as defined by claim 1.

23. The vaccine as defined by claim 22, in combination
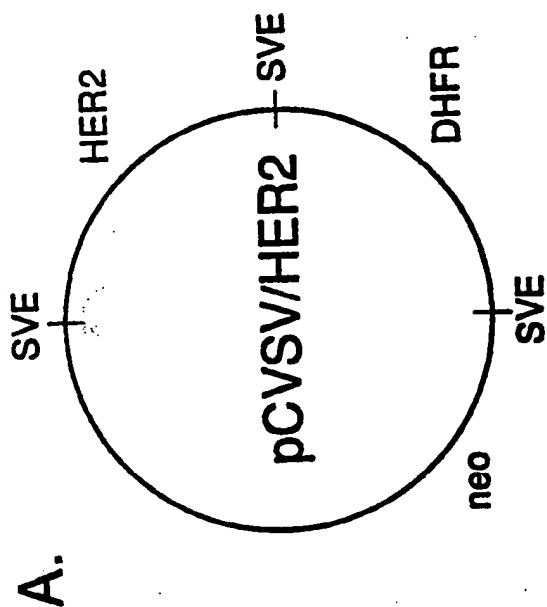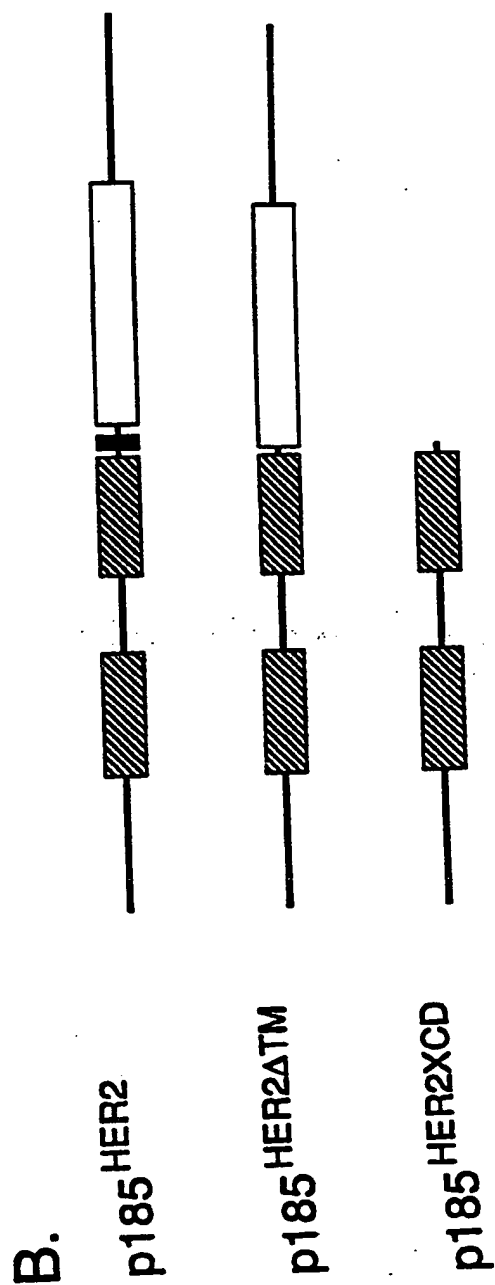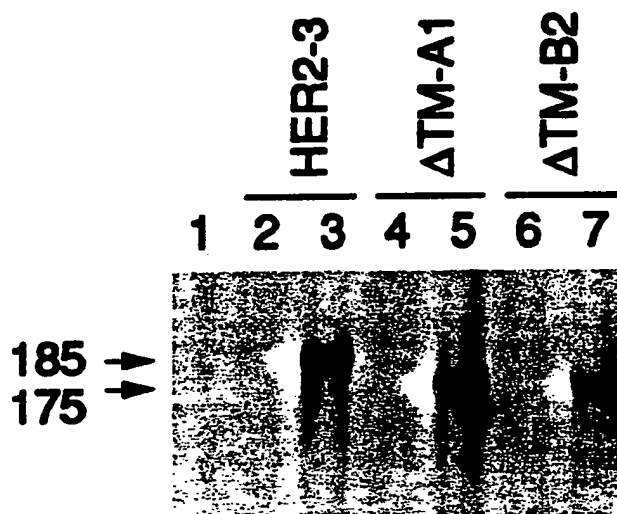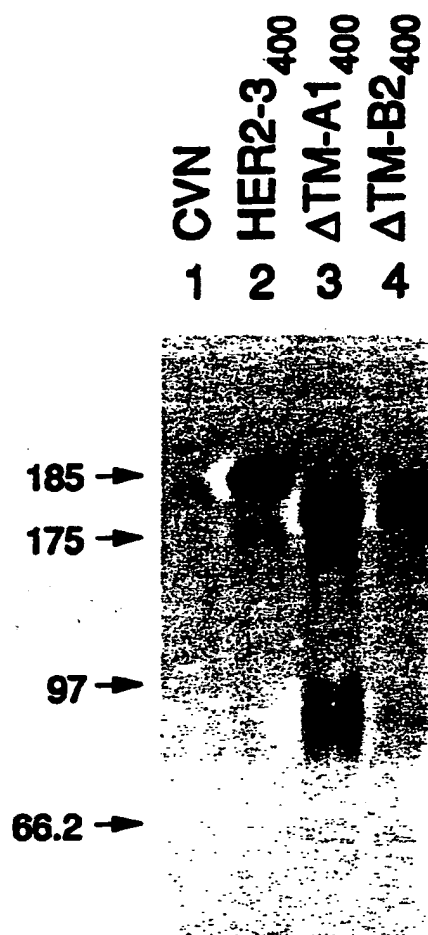
10   with a suitable adjuvant.

24. A vaccine comprising the extracellular portion of the HER2 molecule as defined by claim 2.

25. The vaccine as defined by claim 24, in combination with a suitable adjuvant.

Fig-1A

A. pCVSV/HER2

SVE — HER2 — SVE — pCVSV/HER2 — SVE — DHFR — neo

Fig-1B

B.

p185^HER2

p185^HER2ΔTM

p185^HER2XCD

Fig _ 2

Fig. 3
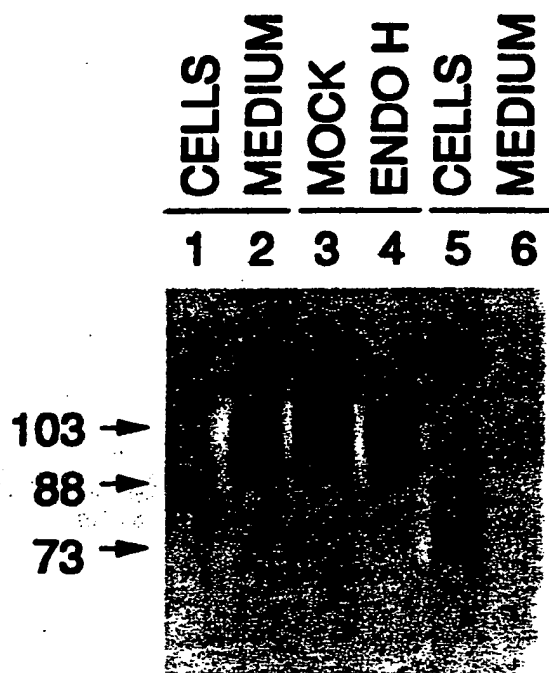
Fig. 4

Fig_ 5

Fig - 6

Fig - 7

Fig- 8C

Fig- 8B

Fig- 8A
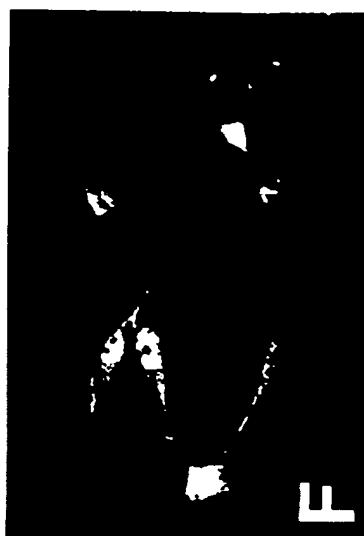
Fig - 8F

Fig- 8E

Fig - 8D

Fig - 9C

Fig - 9B

Fig - 9A

Fig - 9F

Fig - 9E

Fig - 9D

Fig_ 10A

Fig_ 10B

Fig_ 10C

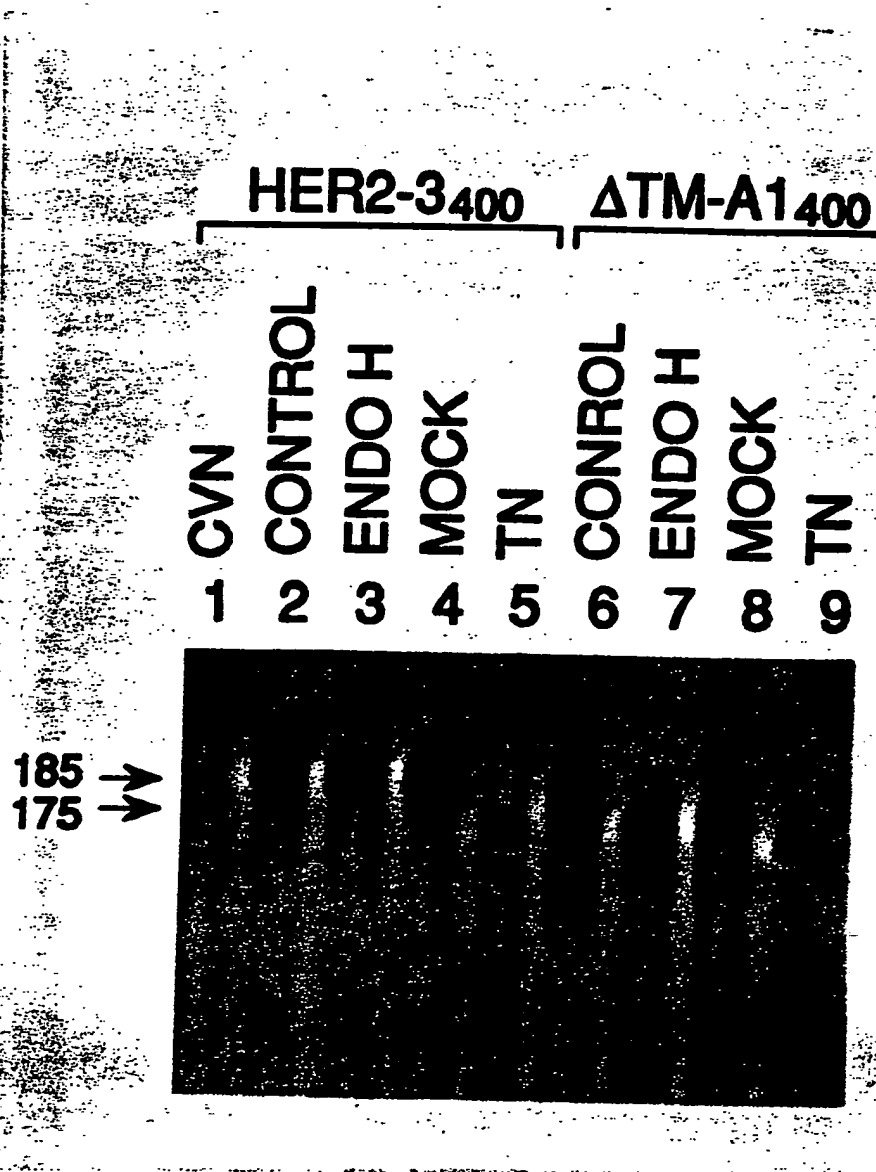Fig - 11

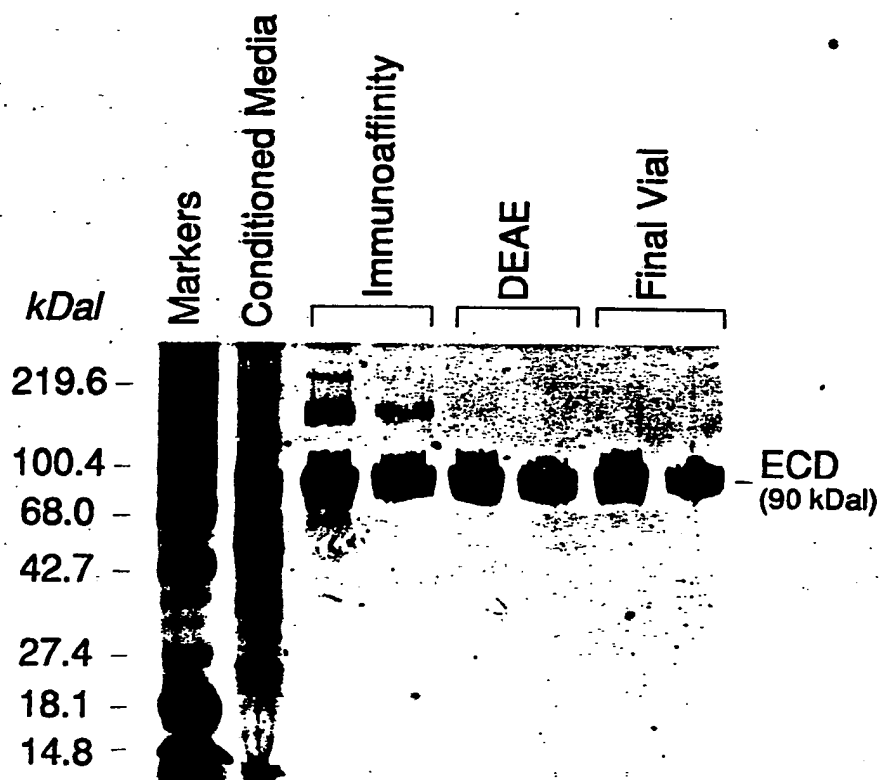# Purification of the HER2 Extracellular Domain

Fig- 12

FIGURE 13

```
  1
SER THR GLN VAL CYS THR GLY THR ASP MET(10) LYS LEU ARG LEU PRO ALA SER PRO GLU THR(20)
AGC ACC CAA GUG UGC ACC GGC ACA GAC AUG     AAG CUG CGG CUC CCU GCC AGU CCC GAG ACC

HIS LEU ASP MET LEU ARG HIS LEU TYR GLN(30) GLY CYS GLN VAL VAL GLN GLY ASN LEU GLU(40)
CAC CUG GAC AUG CUC CGC CAC CUC UAC CAG     GGC UGC CAG GUG GUG CAG GGA AAC CUG GAA

LEU THR TYR LEU PRO THR ASN ALA SER LEU(50) SER PHE LEU GLN ASP ILE GLN GLU VAL GLN(60)
CUC ACC UAC CUG CCC ACC AAU GCC AGC CUG     UCC UUC CUG CAG GAU AUC CAG GAG GUG CAG

GLY TYR VAL LEU ILE ALA HIS ASN GLN VAL(70) ARG GLN VAL PRO LEU GLN ARG LEU ARG ILE(80)
GGC UAC GUG CUC AUC GCU CAC AAC CAA GUG     AGG CAG GUC CCA CUG CAG AGG CUG CGG AUU

VAL ARG GLY THR GLN LEU PHE GLU ASP ASN(90) TYR ALA VAL LEU ALA ASP ASN GLY ASP   (100)
GUG CGA GGC ACC CAG CUC UUU GAG GAU AAU     UAU GCC GUG CUG GCC GAC AAU GGA GAC

PRO LEU ASN ASN THR THR PRO VAL THR GLY(110) ALA SER PRO GLY GLY LEU ARG GLU LEU GLN(120)
CCG CUG AAC AAU ACC ACC CCU GUC ACA GGG      GCC UCC CCA GGA GGC CUG CGG GAG CUG CAG

LEU ARG SER LEU THR GLU ILE LEU LYS GLY(130) VAL LEU ILE GLN ARG ASN PRO GLN LEU LEU(140)
CUU CGA AGC CUC ACA GAG AUC CUG AAA GGA      GUC UUG AUC CAG CGG AAC CCC CAG AAC CUC

CYS TYR GLN ASP THR ILE LEU TRP LYS ASP(150) ILE PHE HIS LYS ASN ASN GLN LEU ALA LEU(160)
UGC UAC CAG GAC ACG AUU CUG UGG AAG GAC      AUC UUC CAC AAG AAC AAC CAG CUG GCU CUC
```

FIGURE   13

```
                                                             170                                      180
THR LEU ILE ASP THR ASN ARG SER ARG ALA CYS HIS PRO CYS SER PRO MET CYS LYS GLY
ACA CUG AUA GAC ACC AAC CGC UCU CGG GCC UGC CAC CCC UGU UCU CCG AUG UGU AAG GGC

                 190                                      200
SER ARG CYS TRP GLY GLU SER SER GLU ASP CYS GLN SER LEU THR ARG THR VAL CYS ALA
UCC CGC UGC UGG GGA GAG AGU UCU GAG GAU UGU CAG AGC CUG ACG CGC ACU GUC UGU GCC

                 210                                      220
GLY GLY CYS ALA ARG CYS LYS GLY PRO THR ASP CYS LEU PRO THR ASP CYS CYS HIS GLY
GGU GGC UGC GCC CGC UGC AAG GGG CCA ACU GAC UGC CUG CCA ACU GAC UGC UGC CAU GGC

                 230                                      240
ALA GLY CYS THR GLY PRO LYS HIS SER ASP CYS LEU ALA CYS LEU HIS PHE ASN HIS SER
GCC GGC UGC ACG GGC CCC AAG CAC AGC GAC UGC CUG GCC UGC CUC CAC UUC AAC CAC AGU

                 250                                      260
GLY ILE CYS GLU LEU HIS CYS PRO ALA LEU VAL THR TYR ASN THR ASP PHE GLU SER SER
GGC AUC UGU GAG CUG CAC UGC CCA GCC CUG GUG ACC UAC AAC ACA GAC UUU GAG UCC UCC

                 270                                      280
MET PRO ASN PRO GLU GLY ARG TYR THR PHE GLY ALA SER CYS VAL THR ALA CYS PHE GLU TYR
AUG CCC AAU CCC GAG GGC CGG UAU ACA UUC GGA GCC AGC UGU GUG ACU GCC UGU UUU GAG UAC

                 290                                      300
ASN TYR LEU SER THR ASP VAL GLY SER CYS THR LEU VAL CYS PRO LEU HIS ASN GLN GLU GLU
AAC UAC CUU ACG UCC GAC GUG GGA UCC UGC ACC CUC GUC UGC CCC CUG CAC AAC CAA GAG GAG

                 310                                      320
VAL THR ALA GLU ASP GLY THR GLN ARG CYS GLU LYS CYS SER LYS PRO CYS ALA ARG VAL
GUG ACA GCA GAG GAU GGA ACA CAG CGG UGU GAG AAG UGC AGC AAG CCC UGU GCC CGA GUG

                 330                                      340
CYS TYR GLY LEU GLY MET GLU HIS LEU ARG GLU VAL ARG ALA VAL THR SER ALA ASN ILE
UGC UAC GGU CUG GGU AUG GAG CAC UUG CGA GAG GUG AGG GCA GUG ACC AGU GCC AAU AUC
```

FIGURE 13

```
                                                                      350                     360
GLN GLU PHE ALA GLY CYS LYS LYS ILE PHE GLY SER  LEU  ALA PHE LEU PRO GLU SER PHE
CAG GAG UUU GCU GGC UGC AAG AAG AUC UUU GGG AGC  CUG  GCA UUU CUG CCG GAG AGC UUU

                                              370                            380
ASP GLY ASP PRO ALA SER ASN THR ALA PRO LEU GLN PRO GLU  GLN LEU GLN VAL PHE GLU
GAU GGG GAC CCA GCC UCC AAC ACU GCC CCG CUC CAA CCA GAG  CAG CUC CAA GUG UUU GAG

     THR LEU GLU GLU ILE  THR GLY TYR LEU TYR  VAL PHE GLN ASN LEU GLN  TRP PRO ASP SER  LEU PRO ASP
     ACU CUG GAA GAG AUC  ACA GGU UAC CUA UAC  GUC UUC CAG AAC CUG CAG  UGG CCG GAC AGC  CUU CCU GAC
                     390                                400

     LEU SER VAL PHE GLN ASN LEU GLN  VAL ILE ARG GLY ILE LEU HIS ASN GLY ALA TYR
     CUC AGC GUC UUC CAG AAC CUG CAG  GUA AUC CGG GGA CGA AUU CUG CAC AAU GGC GCC UAC
                             410                                   420

SER LEU THR LEU GLN GLY ILE LEU HIS LEU ALA LEU ILE HIS HIS THR  GLY LEU  LEU ARG SER LEU ARG GLU
UCG CUG ACC CUG CAA GGG CUG AUC CUC GCC CUG CUC AUC CAU CAC ACC  GGG CUG  CUG AGG UCA CUG AGG GAA
                             430                                         440

GLY SER GLY  LEU ALA LEU ILE HIS HIS ASN THR HIS LEU CYS PHE VAL HIS THR VAL PRO
GGC AGU GGG  CUG GCC CUC AUC CAC CAU AAC ACC CAC CUC UGC UUC GUG CAC ACG GUG CCC
                     450                                   460

TRP ASP GLN LEU PHE ARG ASN PRO HIS ALA LEU LEU HIS THR ALA ASN ARG PRO GLU
UGG GAC CAG CUG UUU CGG AAC CCG CAC GCU CUG CUC CAC ACG GCC AAC CGG CCA GAG
                     470                                   480

ASP GLU CYS VAL GLY LEU ALA CYS HIS GLN LEU CYS ALA ARG GLY HIS CYS TRP
GAC GAG UGU GUG GGC GAG CUG GCC UGC CAC CAG CUG UGC GCC CGA GGG CAC UGC UGG
                     490                                   500

GLY PRO THR GLN CYS VAL ASN SER GLN PHE LEU ARG GLY GLN GLU  CYS VAL
GGU CCA ACC CAG UGU GUC AAC AGC CAG UUC CUU CGG GGC CAG GAG  UGC GUG
                     510                                         520
```

FIGURE 13
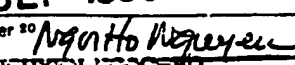
```
                                       530                           540
GLU GLU CYS ARG VAL LEU GLN GLY LEU   PRO ARG GLU TYR VAL ASN ALA ARG HIS CYS LEU
GAG GAA UGC CGA GUA CUG CAG GGG CUG   CCC AGG GAG UAU GUG AAU GCC AGG CAC UGU UUG

                                       550                           560
PRO CYS HIS PRO GLU CYS GLN PRO GLN   ASN GLY SER VAL THR CYS PHE GLY PRO GLU ALA
CCG UGC CAC CCU GAG UGU CAG CCC CAG   AAU GGC UCA GUG ACC UGU UUU GGA CCG GAG GCU

                                       570                           580
ASP GLN CYS VAL ALA HIS TYR LYS ASP   PRO PRO PHE CYS VAL ALA ARG CYS PRO
GAC CAG UGU GUG GCC CAC UAU AAG GAC   CCU CCC UUC UGC GUG GCC CGG UGC CCC

                                       590                           600
SER GLY VAL LYS PRO ASP LEU SER TYR   MET PRO ILE TRP LYS PHE PRO ASP GLU GLY
AGC GGU GUG AAA CCU GAC CUC UCC UAC   AUG CCC AUC UGG AAG UUU CCA GAU GAG GGC

                                       610                           620
ALA CYS GLN PRO CYS PRO ILE ASN CYS   THR HIS SER CYS VAL ASP LEU ASP ASP LYS GLY
GCA UGC CAG CCU UGC CCC AUC AAC UGC   ACC CAC UCC UGU GUG GAC CUG GAU GAC AAG GGC

624
CYS PRO ALA GLU
UCC CCC GCC GAG
```

INTERNATIONAL SEARCH REPORT

International Application No   PCT/US90/02697

I. CLASSIFICATION F SUBJECT MATTER (if several classification symbols apply, indicate all) 3

According to International Patent Classification (IPC) or to both National Classification and IPC

IPC(5):   C07K 7/06, 7/08, 13/00, 17/00; C12N 15/12, 1/19, 1/21 5/10, 15/63
C12P 21/02; A61K 39/00, 39/385, 39/38. U.S.Cl. 530/324-328, 350, 403, 828;

II. FIELDS SEARCHED   435/320, 172, 69.1, 69.3, 252.3, 240.2; 935/12, 22-32, 66-75

Minimum Documentation Searched 4   424/88

Classification System	Classification Symbols
U.S.Cl.	530/324-328, 350, 403, 828; 435/320, 172.3, 69.1, 69.3, 252.3, 240.2; 935/12, 22-32, 66-75; 424/88

Documentation Searched other than Minimum Documentation
to the Extent that such Documents are Included in tho Fields Searched 5

Biosis, World Patents Index, USPTO Automated Patent System (File US PAT, 1975-1990). See attachment for search terms.

III. DOCUMENTS CONSIDERED TO BE RELEVANT 14

Category *	Citation of Document, 16 with indication, where appropriate, of the relevant passages 17	Relevant to Claim No. 18
X Y	Nature (London, UK), Volume 319, Number 605123, Issued 16 January 1986, Yamamoto et al, "Similarity of Protein Encoded by the Human C-erh-B-2 Gene to Epiderimal Growth Factor Receptor", pages 230-234. See Figures 1-3 and final paragraph.	1,2,5,6,9-12 3,4,7,8,13-25
Y	US, A, 4,761,371 (BELL ET AL) 02 August 1988. See the entire document.	7,8,13-21
Y	Journal of Cellular Biochemistry, Supplement 13B, Issued January 1989,Shepard et al, "p185 Her 2 Monoclonal Antibody has Anti-Proliferative Effects in Vitro and Sensitizes Human Breast Tumor Cells to Tumor Necrosis Factor," page 42, abstract D253. See entire document.	3,4,22-25
Y	Biochemistry (Washington, US), Volume 26, number 5, Issued 1987, Yarden et al, "Epidermal Growth Factor Induces Rapid Reversible Aggregation of the Purified Epidermal Growth Factor Receptor", pages 1443-1451. See materials and methods section.	3,4

* Special categories of cited documents: 15

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IV. CERTIFICATION

Date of the Actual Completion of the International Search 8	Date of Mailing of this International Search Report 8
12 JULY 1990	2 6 SEP 1990
International Searching Authority 1	Signature of Authorized Officer 10
RO/US	M. Mosher NGUYEN NGOC-HO INTERNATIONAL DIVISION

III. DOCUMENTS C NSIDERED TO BE RELEVANT   (C NTINUED FR M THE SECOND SHEET)

Category*	Citation of Document, ¹⁶ with indication, where appropriate, of the relevant passages ¹⁷	Relevant to Claim No ¹⁸
Y	Biological Abstracts (Philadelphia, US), Volume 87, Number 10, Issued 15 May 1989, Hudziak et al, "p185 Her 2 Nonoclonal Antibody has Antiproliferative Effects In-Vitro and Sensitizes Human Breast Tumor Cells to Tumor Necrosis Factor", abstract 105430. See entire document.	3,4,22-25
A	Annual Review of Biochemistry (Palo Alto, US), Volume 57, Issued 1988, Yarden et al, "Growth Factor Receptor Kinases", pages 443-78.	1-25

ATTACHMENT TO PCT/US90/02697

<u>SEARCH TERMS</u>

her2, her 2, Ng1, oncogen?, receptor, erb#, erb b, vaccine, pure, purif?,
epidermal growth factor, egf, extra cell?, eternal, ligand, domain,
domains, sequence, C erb B 2, erbb2

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